

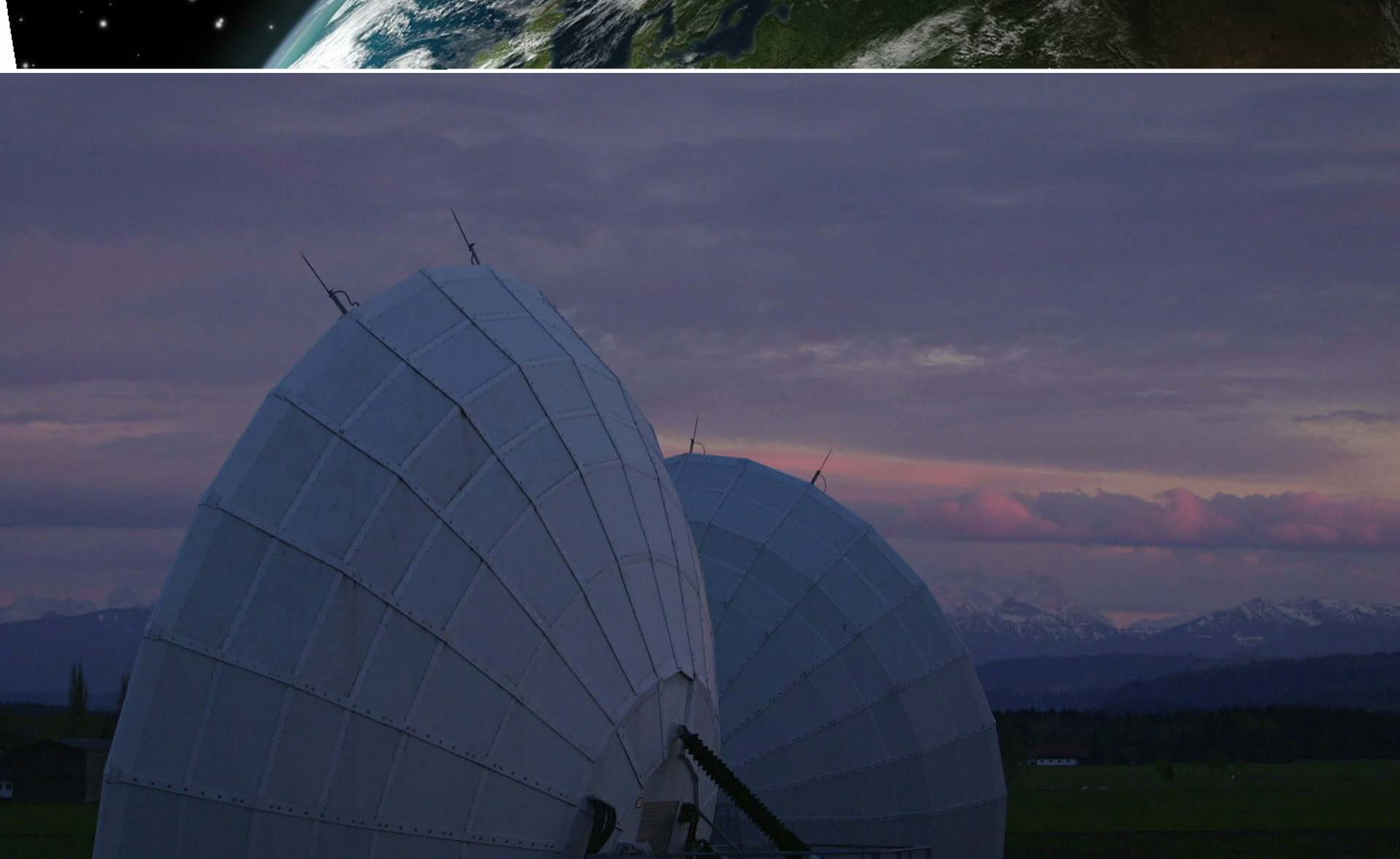
New Paradigms Offering New Earth Observation Opportunities

Mihai Datcu, Gottfried Schwarz



Wissen für Morgen

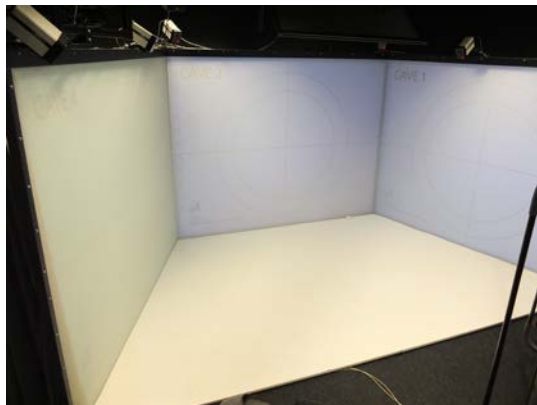
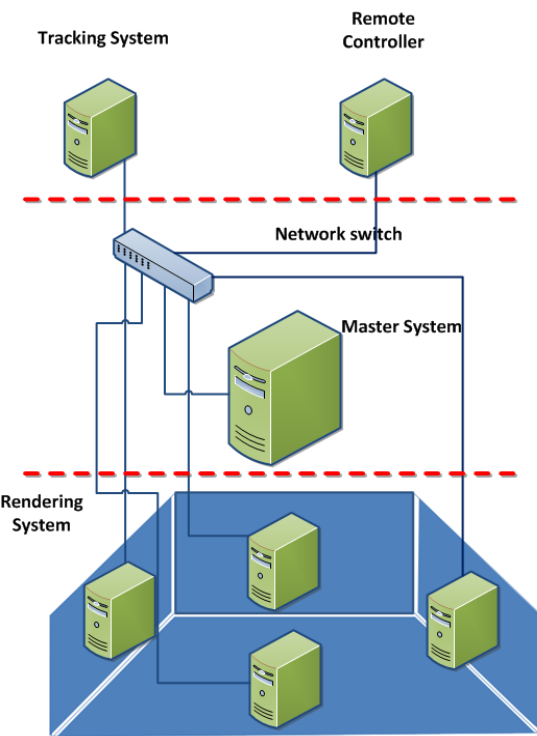




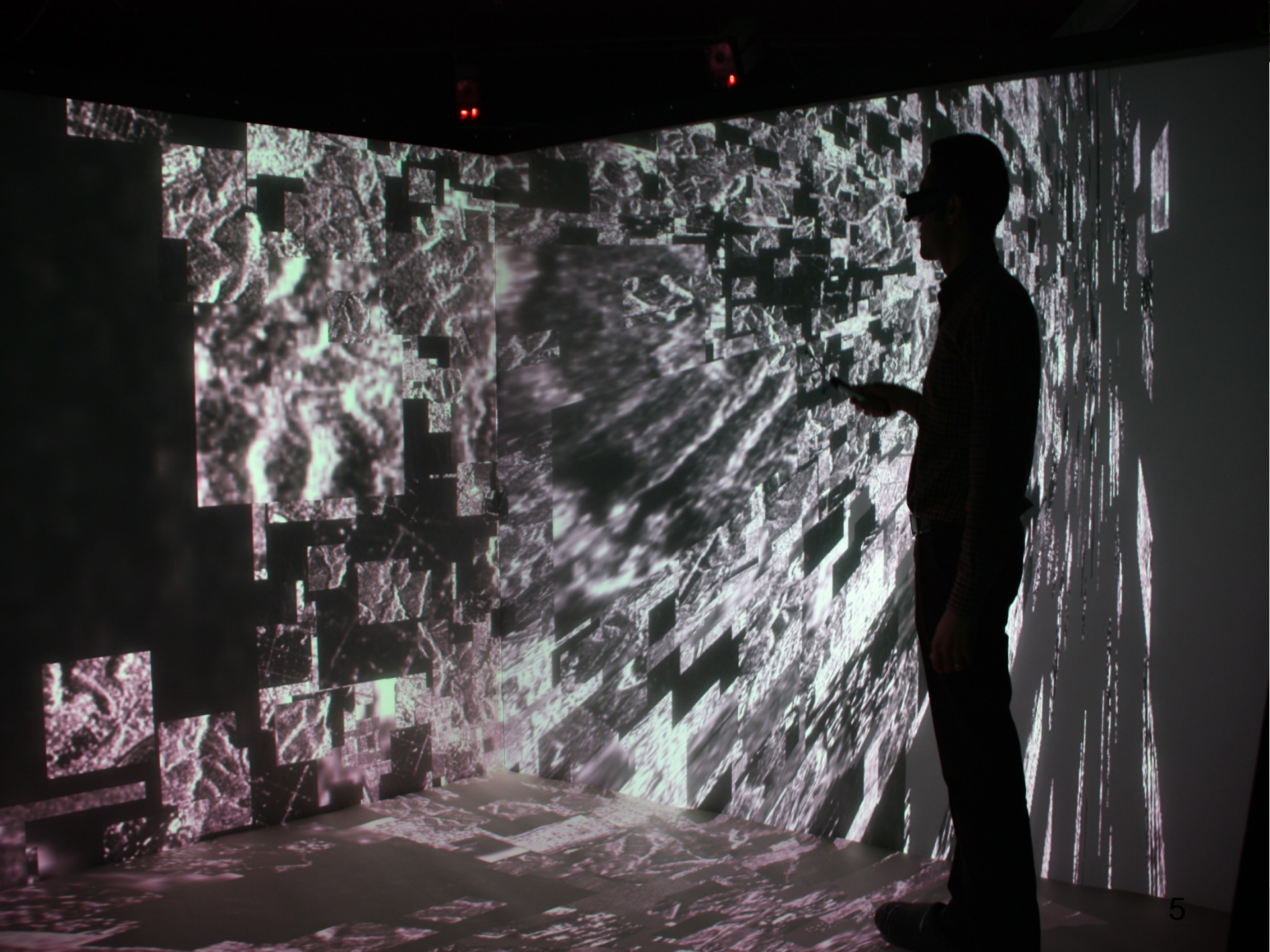
Big Earth Data, acknowledgement: ARD and Professor Peter Baumann, Jacobs University

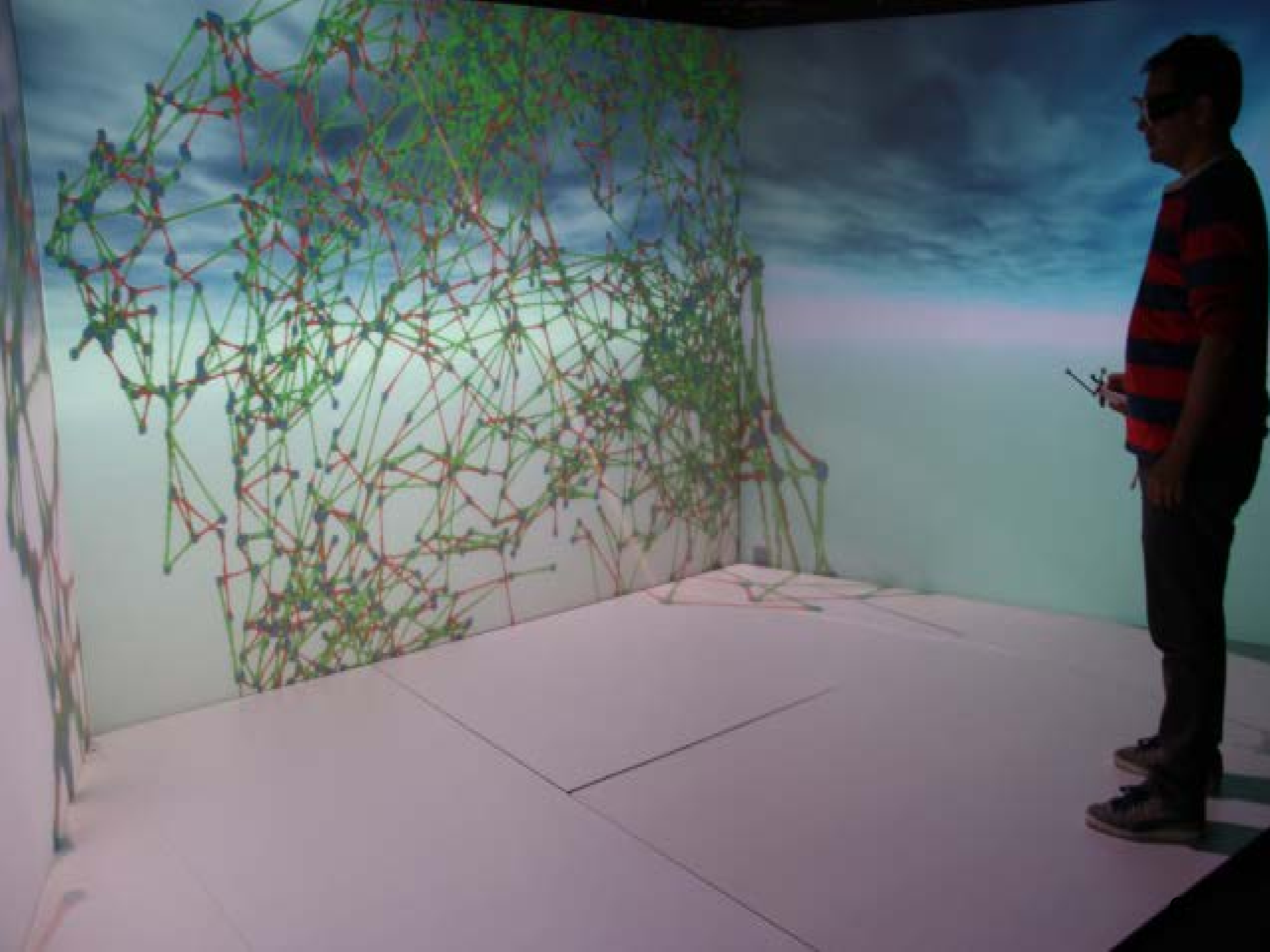


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GOAL

**Applying information theoretical methods
globally and jointly
to the sensing and sensor data understanding**





Data
Science

Artificial
Intelligence

Information
Architecture

Computational
Imaging

Computational
Sensing

Computational
Intelligence





Data
Science

Artificial
Intelligence


Information
Architecture

Computational
Imaging

Computational
Sensing

Computational
Intelligence





A Mathematical Theory of Communication

By C. E. SHANNON

INTRODUCTION

THE recent development of various methods of modulation such as PCM and PPM which exchange bandwidth for signal-to-noise ratio has intensified the interest in a general theory of communication. A basis for such a theory is contained in the important papers of Nyquist¹ and Hartley² on this subject. In the present paper we will extend the theory to include a number of new factors, in particular the effect of noise in the channel, and the savings possible due to the statistical structure of the original message and due to the nature of the final destination of the information.

The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point. Frequently the messages have *meaning*; that is they refer to or are correlated according to some system with certain physical or conceptual entities. These semantic aspects of communication are irrelevant to the engineering problem. The significant aspect is that the actual message is one *selected from a set* of possible messages. The system must be designed to operate for each possible selection, not just the one which will actually be chosen since this is unknown at the time of design.



EO Signal Processing

- Signal processing: the notion and character of a **signal** itself is now **any representation of information**.
- Connect with **ubiquitous** applications
- Symbiosis of **signal processing and machine/stat. learning**
- The back bone: **sampling, sensing, communicating, navigating, visualizing, and interpreting vast amounts of information.**

The grand challenge: information discovery in the Zetabyte era.

Biing Hwang Juang, Quantification and Transmission of Information and Intelligence History and Outlook, IEEE SSM, July 2011

José M.F. Moura, James L. Flanagan Nikil S. Jayant, The Discipline of Signal Processing, IEEE SPM Nov. 2013

Mos Kaveh ,Li Deng, The Discipline of Signal Processing: Part 2, IEEE SPM, Jan. 2014

Alan S. Willsky, Paths Ahead in the Science of Information and Decision Systems, IEEE SPM, March 2010



Information & Intelligence

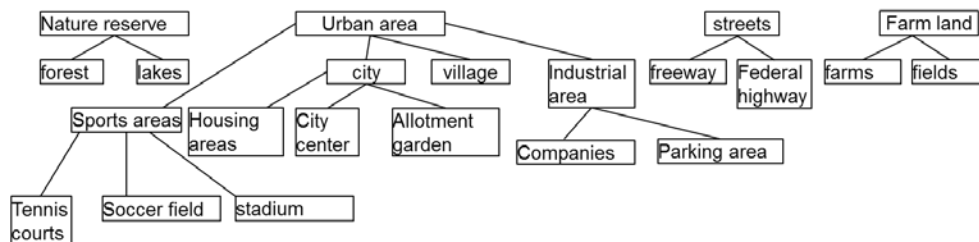
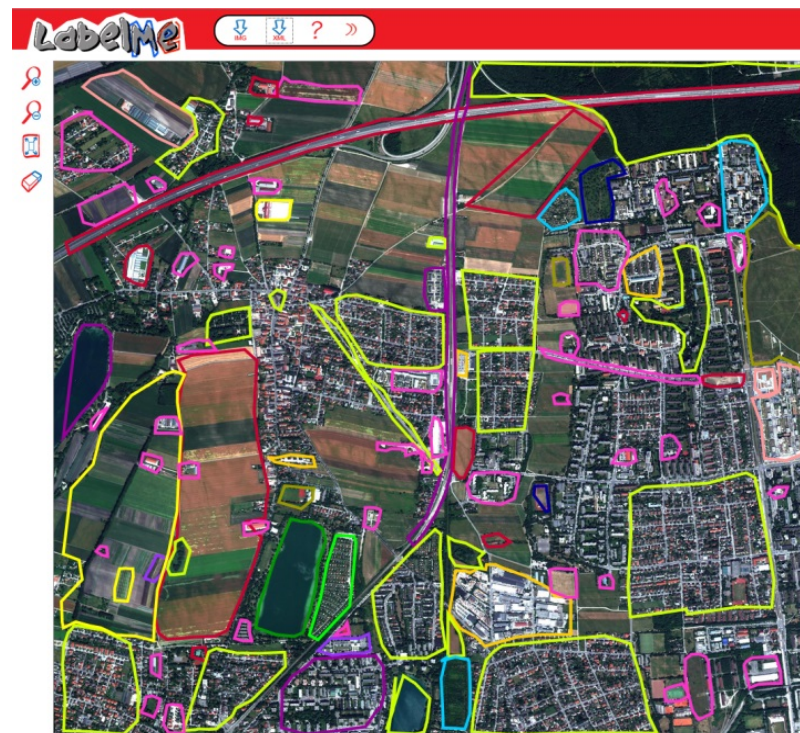
- Humans in the loop: articulation and intelligibility
- Conclusion from the Shannon game: the useful context in English is as short as 3 letters!
- How to quantify and deal with intelligence and knowledge in information theory
- How do we define error in the transmission of intelligence?
- How can the code set (e.g., constellation) and signal shaping be defined to support optimal transmission of intelligence?
- How can the receiver be designed to optimally accomplish reception of intelligence?

User Perceptions – EO Big Data Psychology

Psychological Objective: Minimal group paradigm was applied to enhance the salience of the task context. As a result, participants appeared more willing to continue engaging in the annotation task. In the sense of design based research, these findings have implications for designing practice environments that are more highly accepted by experts.

Experimental Set-Up: Participants presented with this WV2 image, and asked “what do you see?”. They did a “free text” annotation. A sample of 11 images was analyzed, and it included: 116 unique labels, 634 polygons, gathered over 10 hours, 17 min., and 8 secs.

Selected Results: Work toward creating a reference data set for EO images, noting differences between the state of the art in multimedia research: Sensor, Resolution, Perspective, Temporal, Nomenclature, Scale, Background, Methodologies for Annotation



Sample of a semantic hierarchy

The EO context

Earth Observation data is always **used jointly** with information extracted from **other sources** such as GIS, in-situ observations, or maps.

The goal is the exploration of these data and the **timely delivery** of focused **information and knowledge** in a simple understandable format.

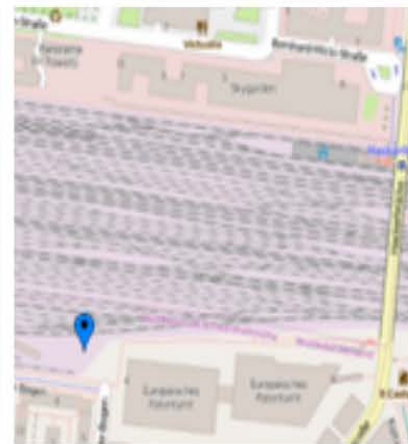
The data volumes, their heterogeneity, unstructured nature and their complexity have become a major Big EO Data challenge for all applications.



(a) SAR



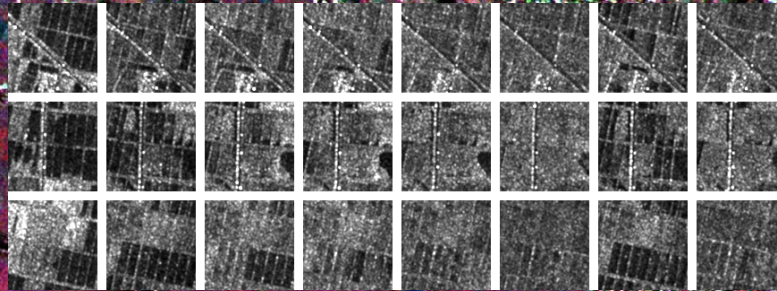
(b) Multispectral



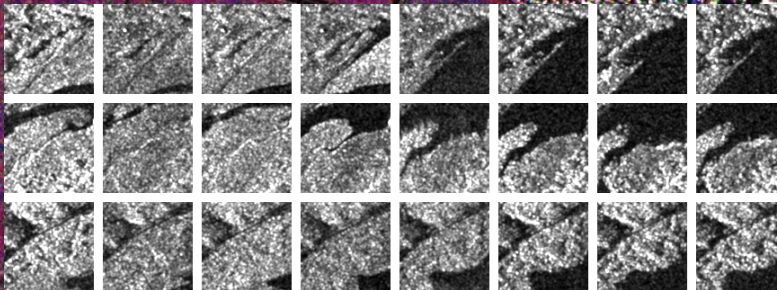
(c) Map - OpenStreetMap



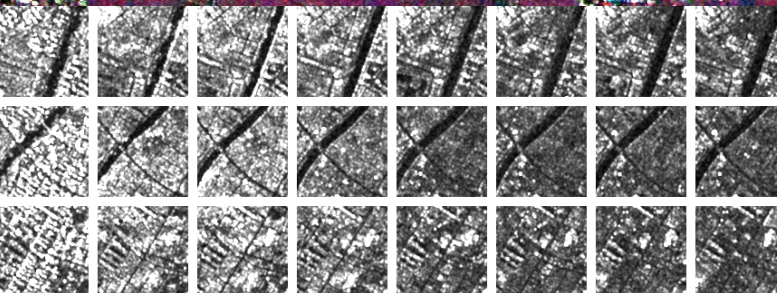
(d) LUCAS



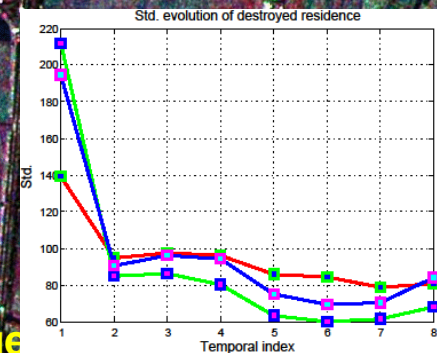
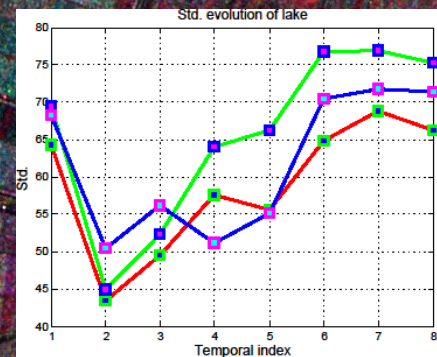
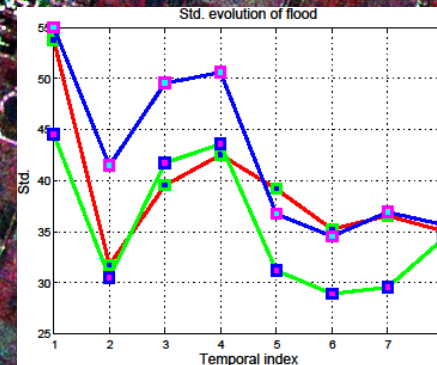
(a) Flood



(b) Lake



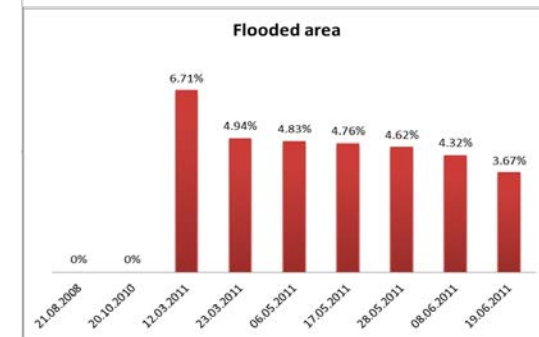
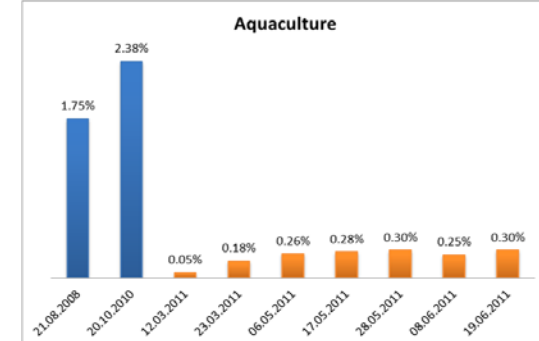
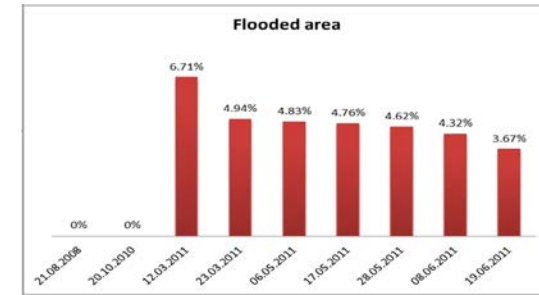
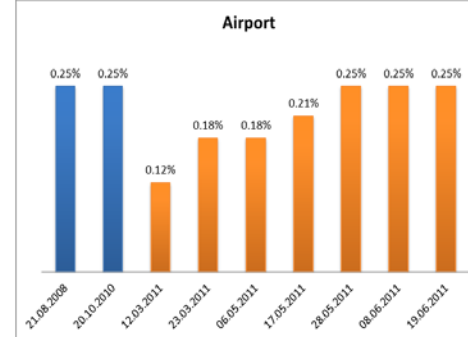
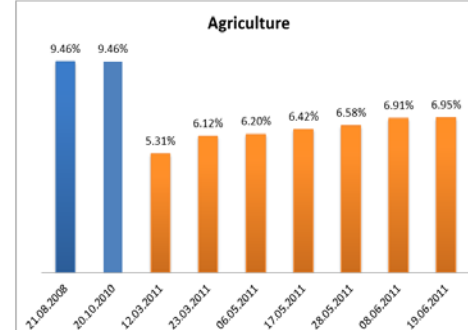
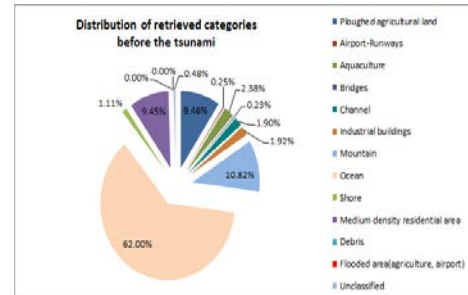
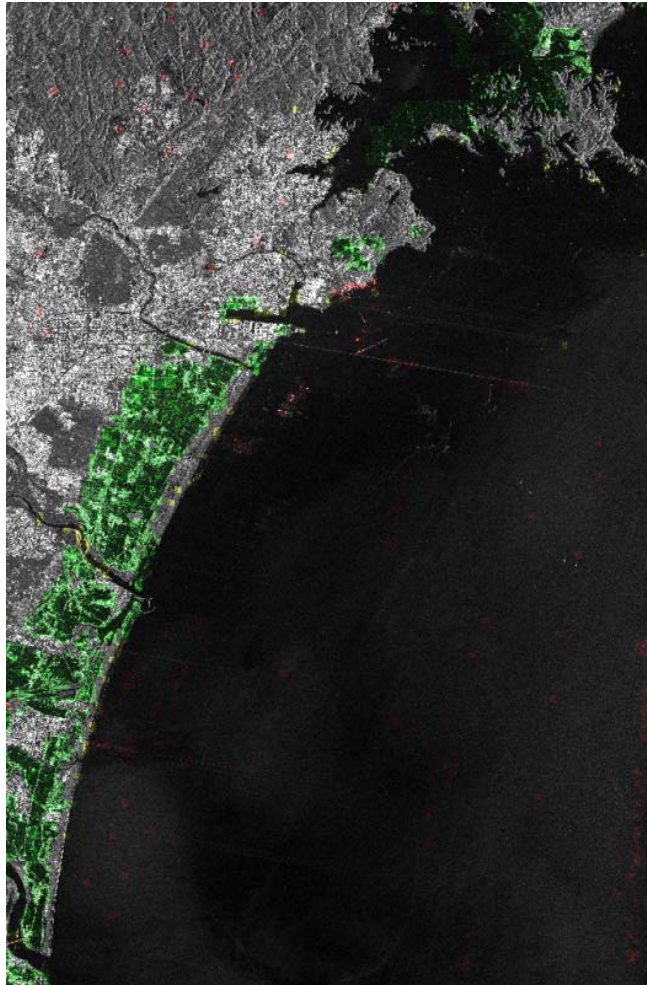
(c) Buildings



Color animation of Multi-temporal TerraSAR-X image (Sendai, Japan, 2011)

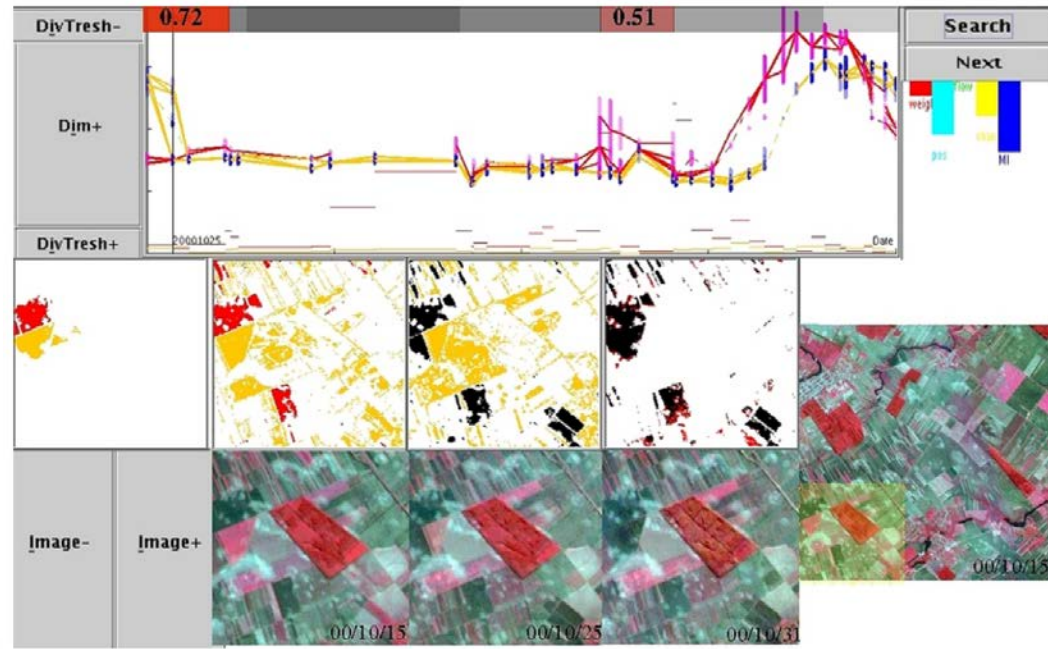
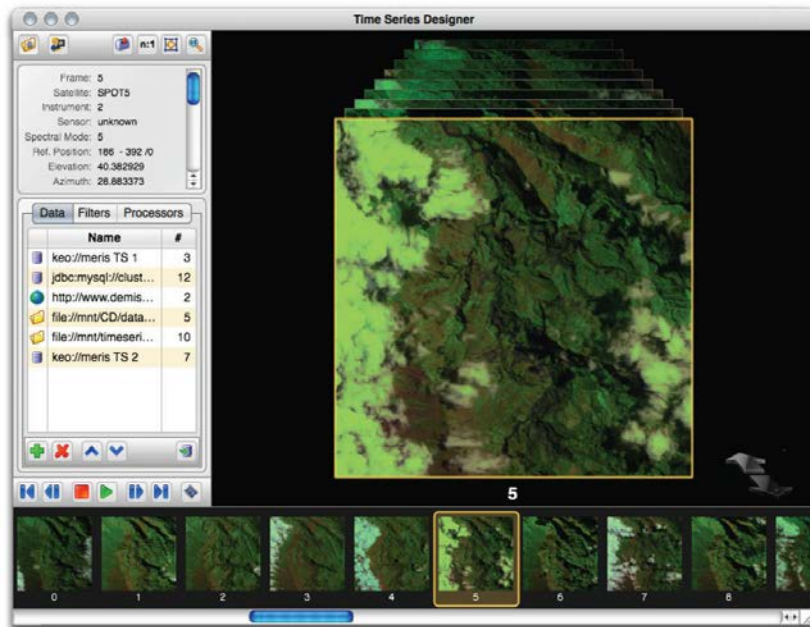
every 11 days,

Data Analytics: Tsunami effects assessment



Time Series Visual Analytics

Time Series Indexing and Visualization

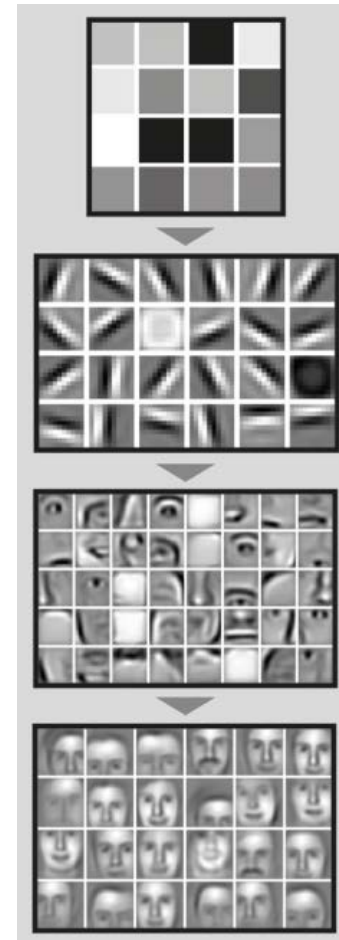
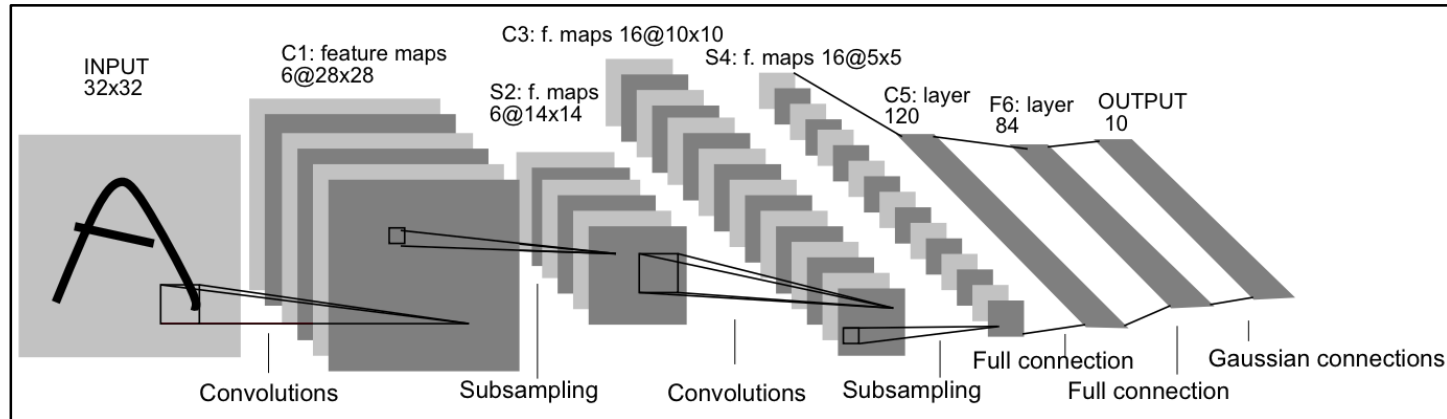


Spatio-temporal patterns learning and Visualization



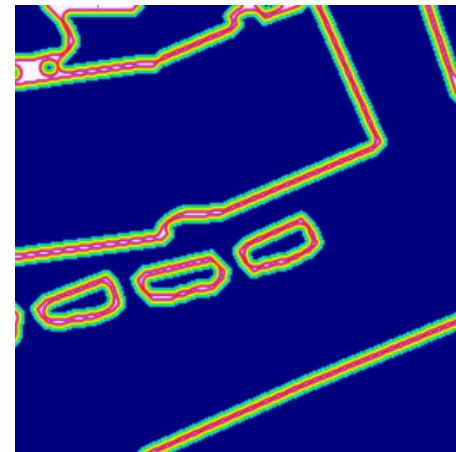
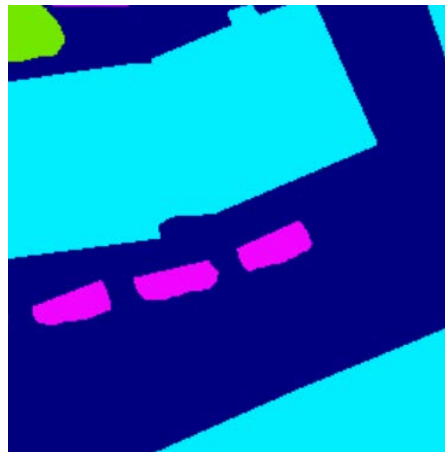
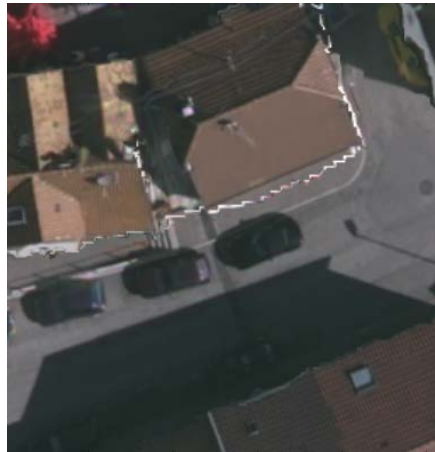
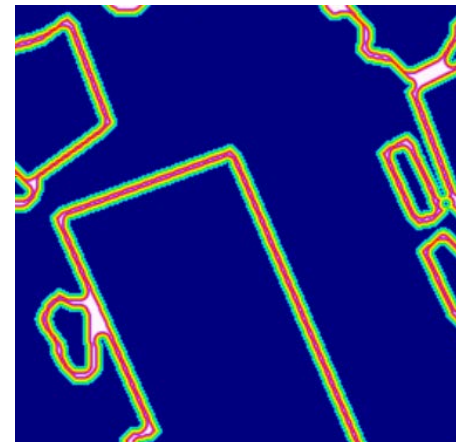
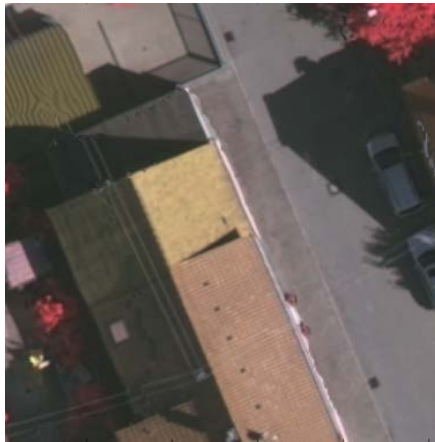
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How CNNs Work ?



- Architecture designed for processing data with spatial consistency – local trainable kernels
- Learn **hierarchical representations** → depth of network
- Efficient for large images extents– local computations through **shared weights** (trainable kernels)

Learning with Class-Boundaries



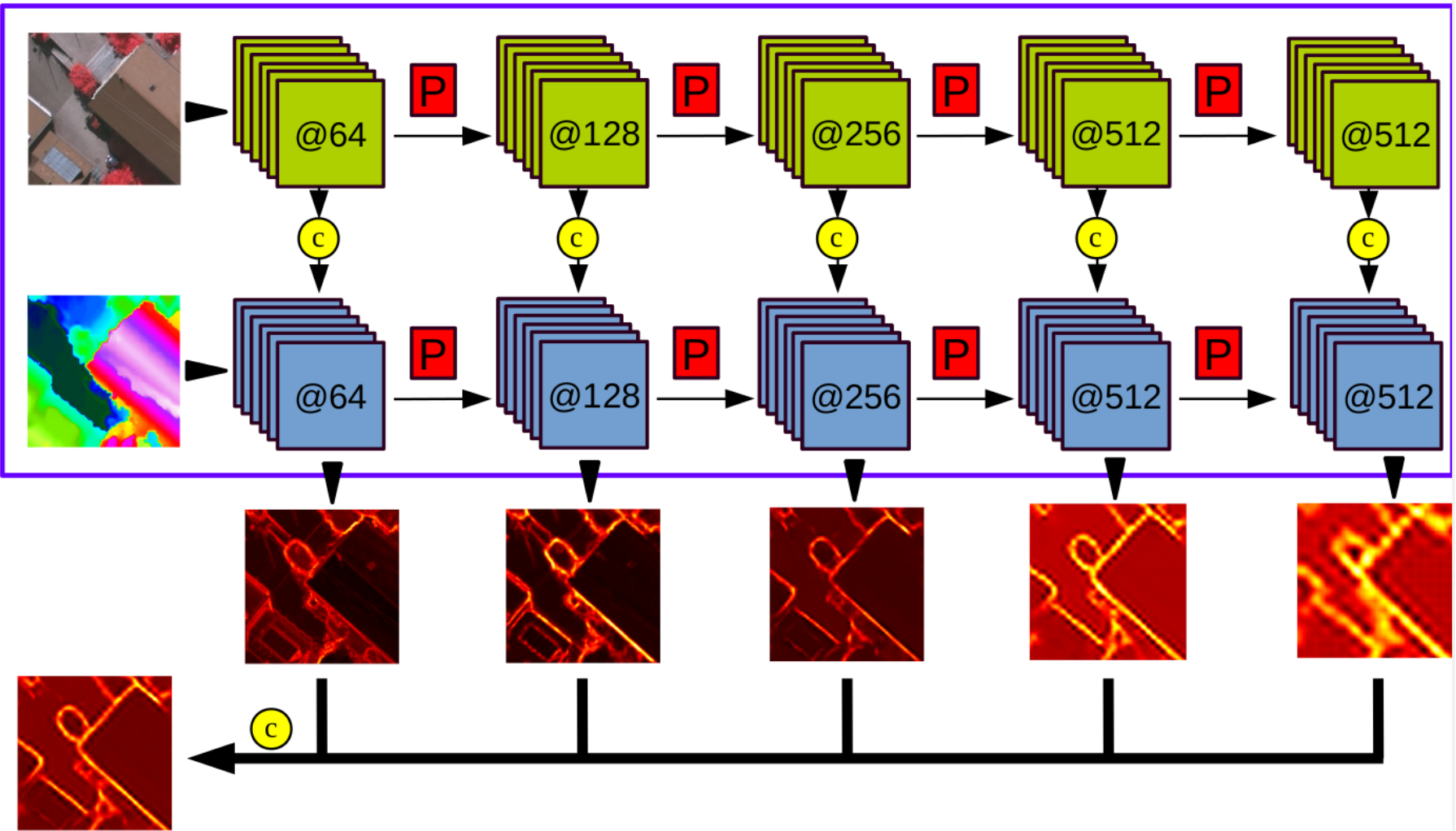
Image

Annotation GT Labels

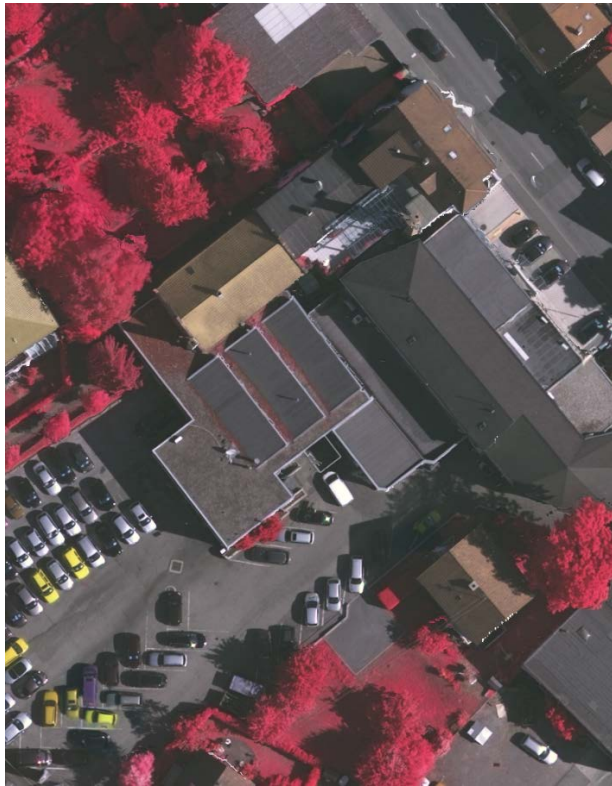
Class-Boundary Labels

Dimitris Marmanis, et al

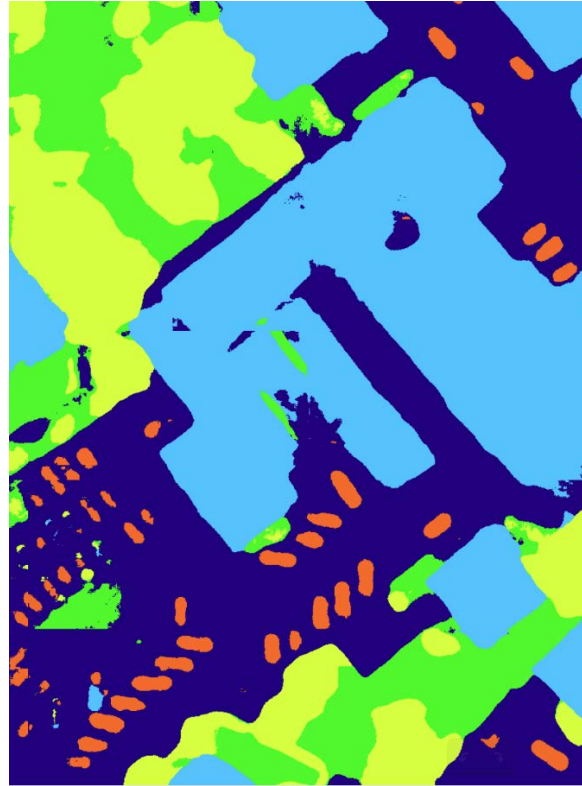
Class-Boundary CNN Model – Architecture



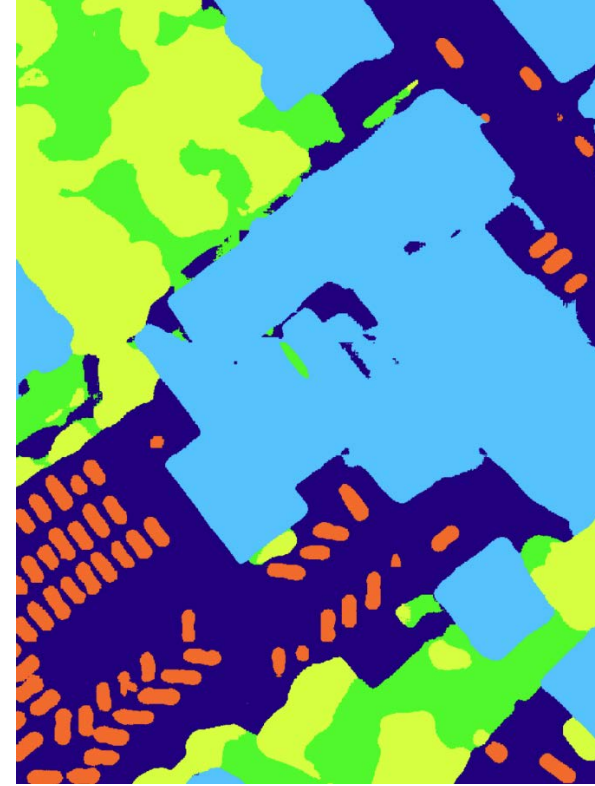
Qualitative Evaluation – CB-CNN vs CNN



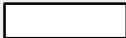




Input Image



Plain Annotation CNN

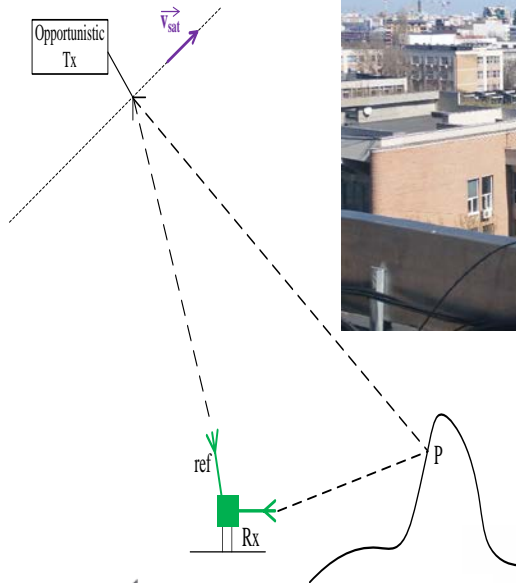
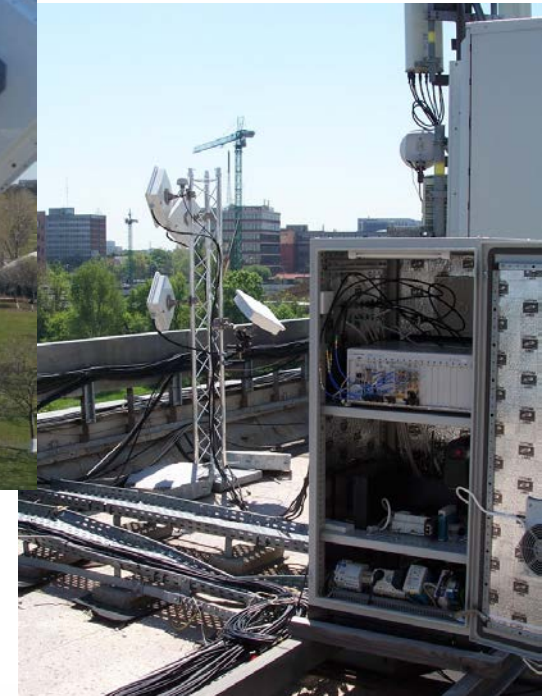


CB & Annotation CNN

<u>Class Coding</u>				
<i>Impervious</i>	<i>Building</i>	<i>Tree</i>	<i>Low Veg.</i>	<i>Car</i>
				

Ground-based bistatic receiver

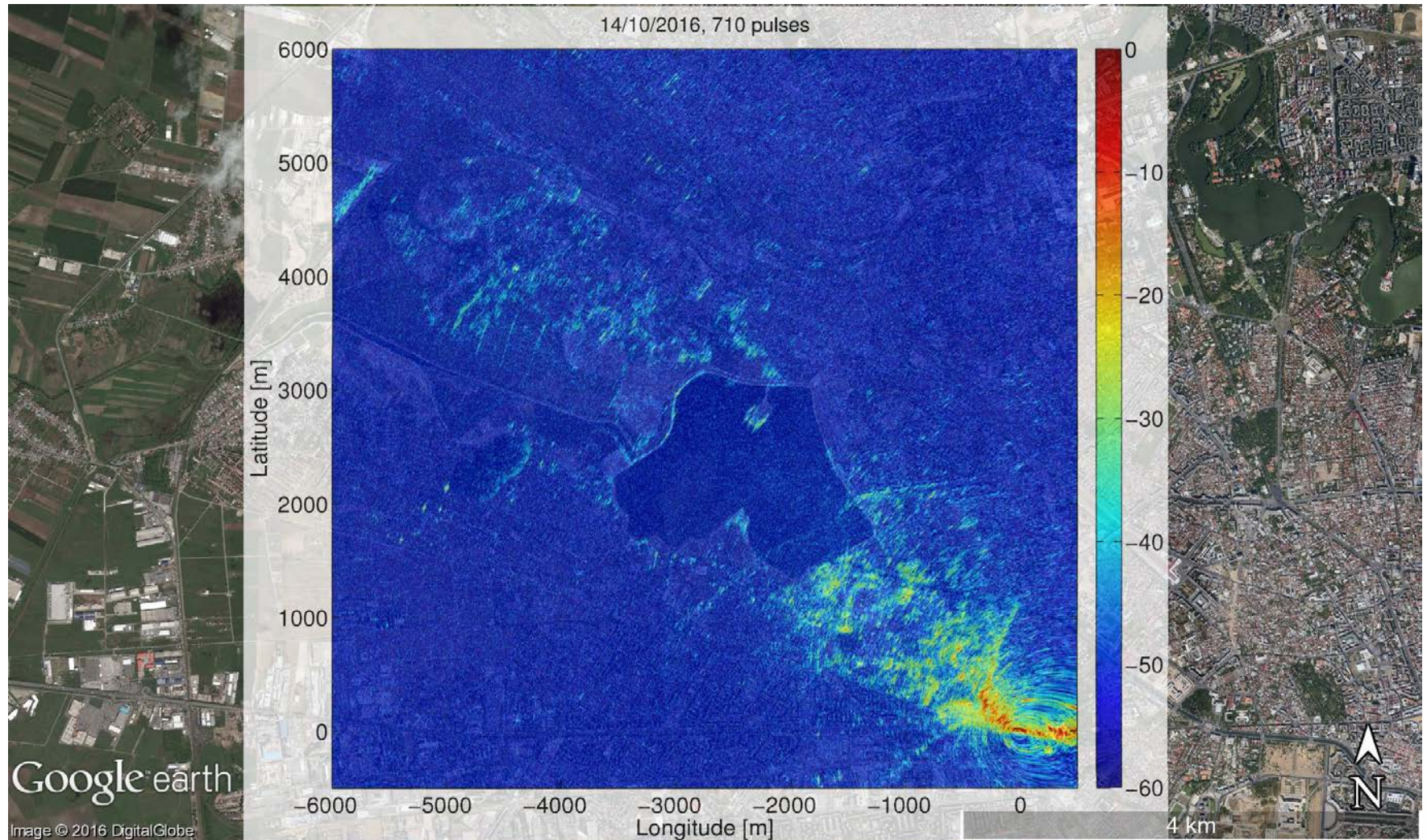
- Modular platform based on a PXI Express chassis (M9018A PXIe).
- 4 channels with 200 MHz instantaneous bandwidth.
- Upgradeable by software reconfiguration/modules replacement.



Remus Cacoveanu, Andrei Anghel UPB, CEOSpaceTech

Bistatic SAR imaging

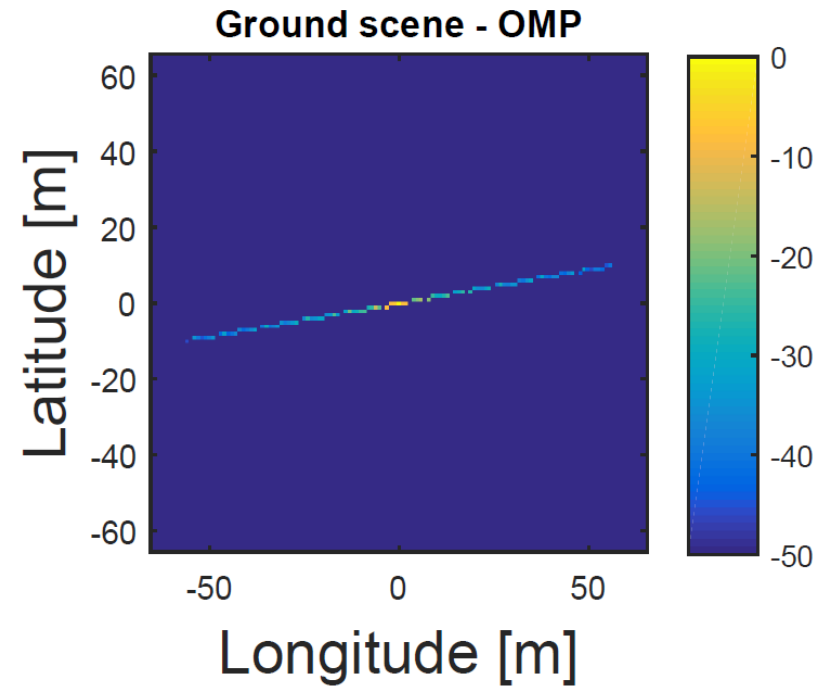
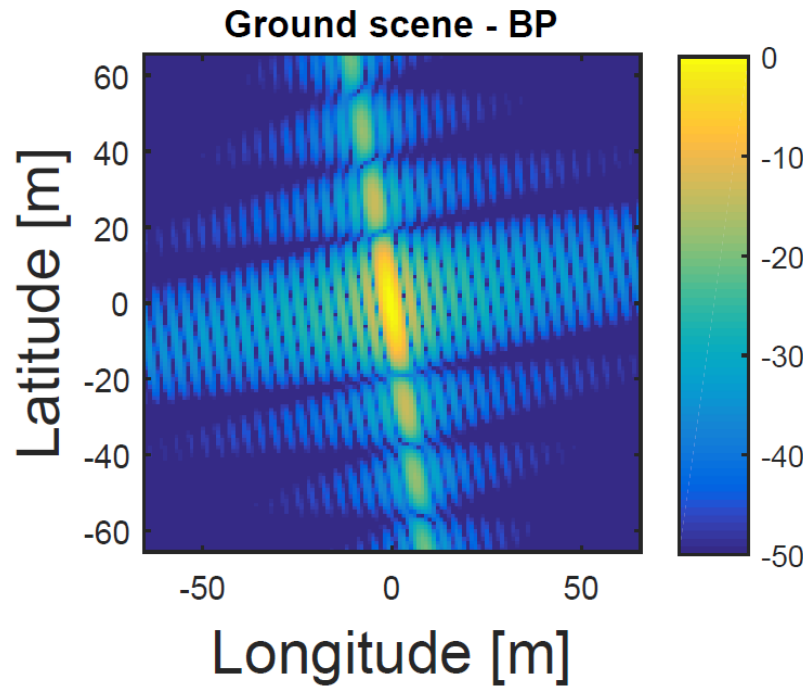
14/10/2016, Sentinel 1A, Descending orbit, Az. 98° , El. 49°



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CS Image Reconstruction

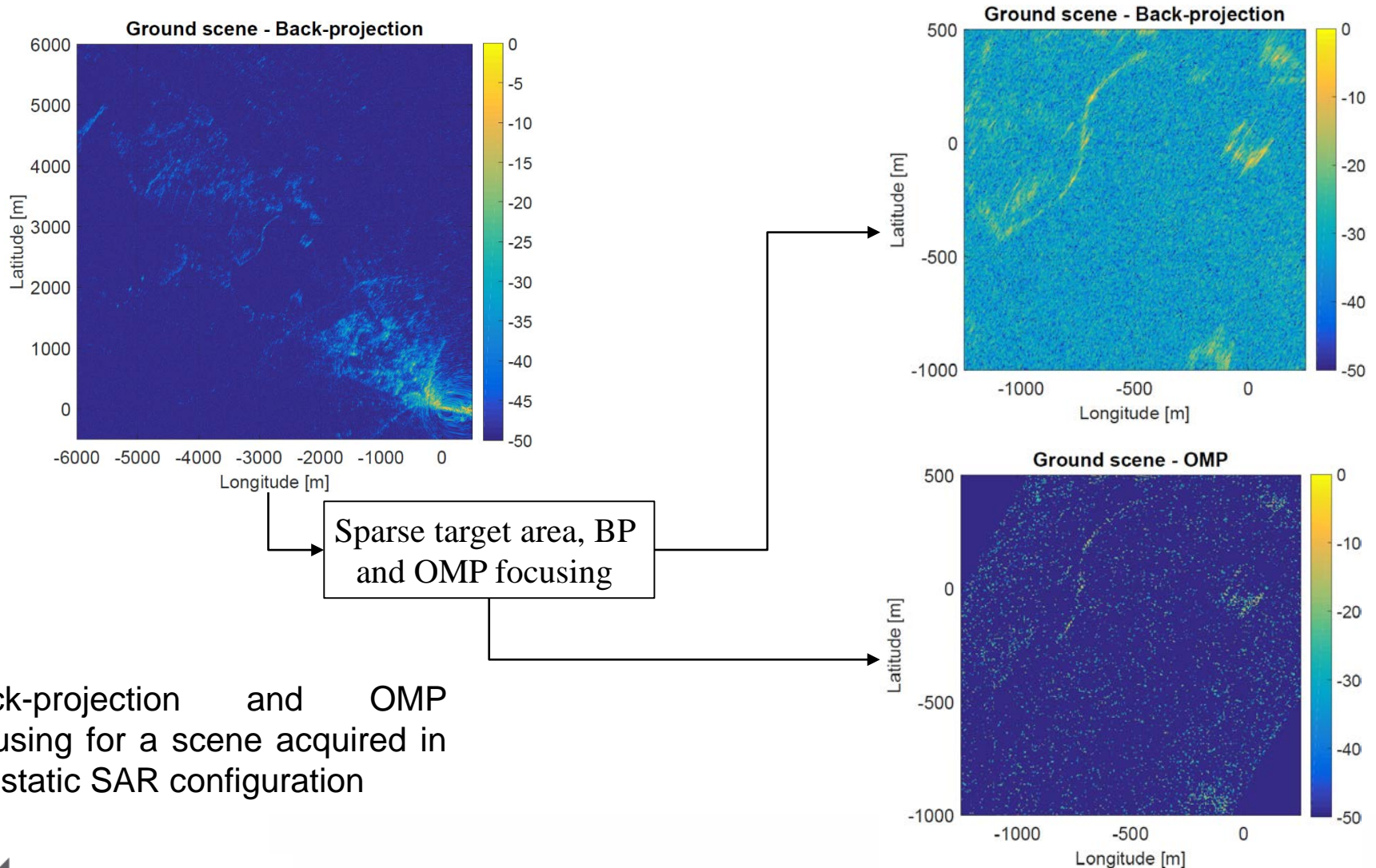
Image reconstruction for one simulated target



Back-projection and OMP focusing for a single target

Elena Dobre, Andrei Anghel, UPB CEOSapceTech

CS Image Reconstruction

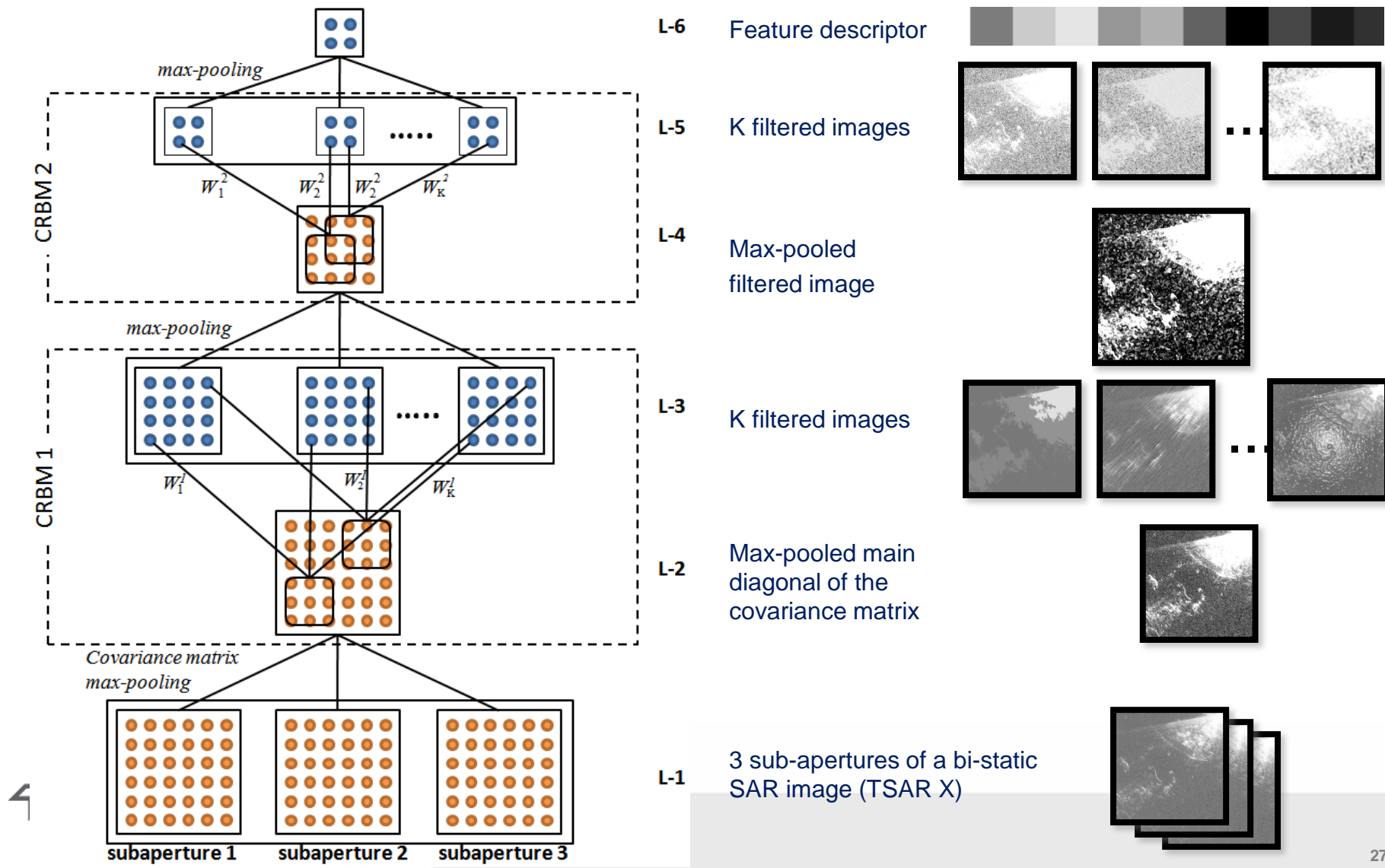


Back-projection and OMP focusing for a scene acquired in a bistatic SAR configuration

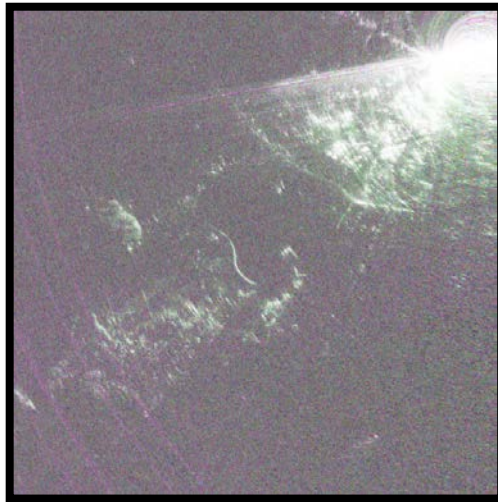


Convolutional Deep Belief Network for Bistatic SAR

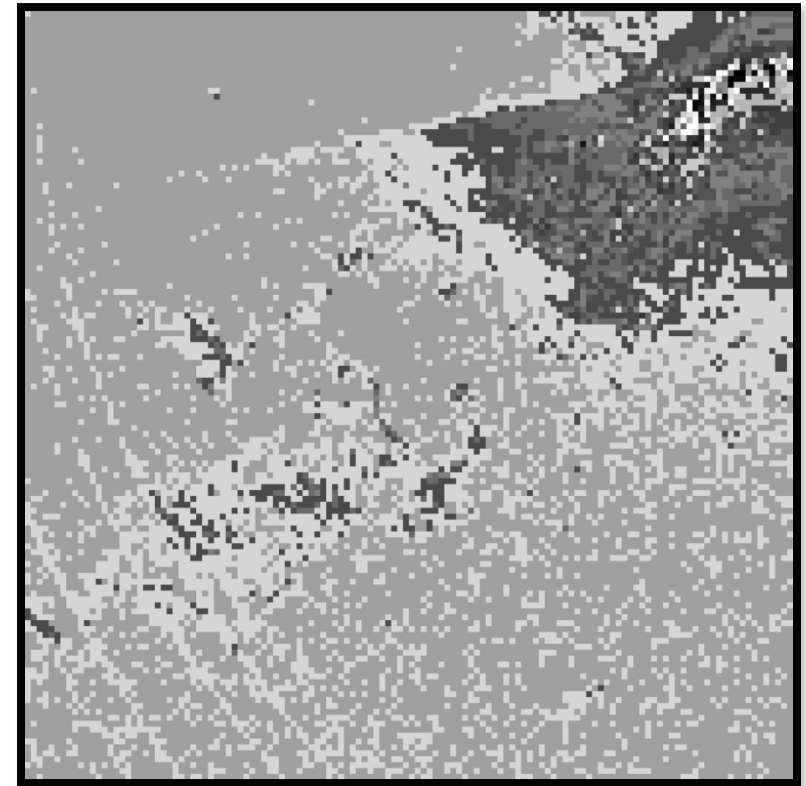
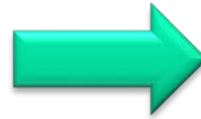
A **convolutional deep belief network (CDBN)** is a stack of Convolutional Restricted Boltzmann Machines in which the output of a CRBM represents the input of the next one.



Unsupervised classification of the extracted features



False-color (covariance matrix)



K-Means classification of the extracted features (25x25 px patches)



Google Earth ground-truth



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